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Digital Audio Broadcasting (DAB); DAB audio coding (MPEG Layer II)

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Foreword

This Technical Specification (TS) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECTrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE 1: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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The Eureka Project 147 was established in 1987, with funding from the European Commission, to develop a system for the broadcasting of audio and data to fixed, portable or mobile receivers. Their work resulted in the publication of European Standard, ETSI EN 300 401 [1], for DAB (see note 2) which now has worldwide acceptance.

NOTE 2: DAB is a registered trademark owned by one of the Eureka Project 147 partners.

The DAB family of standards is supported by WorldDAB, an organization with members drawn from broadcasting organizations and telecommunication providers together with companies from the professional and consumer electronics industry.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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1 Scope

The present document defines the method to code and transmit audio services using the MPEG Layer II audio coder for Digital Audio Broadcasting (DAB) (ETSI EN 300 401 [1]) and details the necessary mandatory requirements for decoders. The permitted audio modes and the data protection and encapsulation are detailed. This audio coding scheme permits the full use of the PAD channel for carrying dynamic labels and user applications.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <https://docbox.etsi.org/Reference/>.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

- [1] ETSI EN 300 401 (V2.1.1): "Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers"
- [2] ISO/IEC 11172-3 (1993): "Information technology - Coding of moving pictures and associated audio for digital storage media at up to 1,5 Mbit/s - Part 3: Audio".
- [3] IEC 60958 (all parts): "Digital audio interface".
- [4] ISO/IEC 13818-3: "Information technology - Generic coding of moving pictures and associated audio information - Part 3: Audio".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definition of terms, abbreviations, mathematical symbols and convention

3.1 Terms

For the purposes of the present document, the terms given in ETSI EN 300 401 [1] and the following apply:

alias component: mirrored signal component resulting from sub-Nyquist sampling

audio bit stream: sequence of consecutive audio frames

audio frame: frame of a duration of 24 ms (at 48 kHz sampling frequency) or of 48 ms (at 24 kHz sampling frequency) which contains a Layer II encoded audio signal ISO/IEC 11172-3 [2], ISO/IEC 13818-3 [4], corresponding to 1 152 consecutive audio samples

NOTE: It is the smallest part of the audio bit stream which is decodable on its own.

audio mode: audio coding system provides single channel, stereo and joint stereo audio modes

NOTE: In each mode, the complete audio signal is encoded as one audio bit stream.

bark: unit of the critical band

NOTE: The Bark scale is a non-linear mapping of the frequency scale over the entire audio frequency range.

bit allocation: time-varying assignment of bits to samples in different sub-bands according to a psychoacoustic model

bound: lowest sub-band in which Intensity stereo coding is used, in the case of joint stereo mode

Common Interleaved Frame (CIF): serial digital output from the main service multiplexer which is contained in the Main Service Channel part of the transmission frame

NOTE: It is common to all transmission modes and contains 55 296 bits (i.e. 864 CUs).

convolutional coding: coding procedure which generates redundancy in the transmitted data stream in order to provide ruggedness against transmission distortions

critical band: psychoacoustic measure in the frequency domain which corresponds to the frequency selectivity of the human ear

DAB audio frame: Same as audio frame, but includes all specific DAB audio-related information.

dual channel mode: audio mode, in which two audio channels with independent programme contents are encoded within one audio bit stream

NOTE: This audio mode is not used in DAB.

Equal Error Protection (EEP): error protection procedure which ensures a constant protection of the bit stream

Extended Programme Associated Data (X-PAD): extended part of the PAD carried towards the end of the DAB audio frame, immediately before the Scale Factor Cyclic Redundancy Check (CRC)

NOTE: Its length is variable.

Fixed Programme Associated Data (F-PAD): fixed part of the PAD contained in the last two bytes of the DAB audio frame

intensity stereo coding: method of exploiting stereo irrelevance or redundancy in stereophonic audio programmes

NOTE: It is based on retaining only the energy envelope of the right and left channels at high frequencies. At low frequencies, the fine structure of the left and right channel of a stereophonic signal is retained.

joint stereo mode: audio mode, in which two channels forming a stereo pair (left and right) are encoded within one bit stream and for which stereophonic irrelevance or redundancy is exploited for further bit reduction

NOTE: The method used in the DAB system is Intensity stereo coding.

logical frame: data burst, contributing to the contents of a sub-channel, during a time interval of 24 ms

EXAMPLE: Data bursts at the output of an audio encoder, a Conditional Access scrambler and a convolutional encoder are referred to as logical frames. The number of bits contained in a specific logical frame depends on the stage in the encoding process and the bit rate associated with the sub-channel.

Main Service Channel (MSC): channel which occupies the major part of the transmission frame and which carries all the digital audio service components, together with possible supporting and additional data service components

masking: property of the human auditory system by which an audio signal cannot be perceived in the presence of another audio signal

masking threshold: function of frequency and time, specifying the sound pressure level below which an audio signal cannot be perceived by the human auditory system

N: length of Fast Fourier Transform (FFT)

polyphase filter bank: set of equal-bandwidth filters with special phase relationship, allowing for efficient implementation of a filter bank

Programme Associated Data (PAD): information which is related to the audio data in terms of contents and synchronization

NOTE: The PAD field is located at the end of the DAB audio frame.

protection level: level specifying the degree of protection, provided by the convolutional coding, against transmission errors

protection profile: scheme of convolutional coding applied

psychoacoustic model: mathematical model of the masking behaviour of the human auditory system

Scale Factor (ScF): factor by which a set of values is scaled before quantization

NOTE: The numerical code for the Scale Factor is called the Scale Factor Index.

Scale Factor Select Information (ScFSI): 2-bit code which indicates for each sub-band how many Scale Factors are coded within the audio frame

service: user-selectable output which can be either a programme service or a data service

service component: part of a service which carries either audio (including PAD) or data

NOTE: The service components of a given service are linked together by the Multiplex Configuration Information. Each service component is carried either in a sub-channel or in the Fast Information Data Channel.

side information: information in the encoded audio bit stream which is necessary for controlling the audio decoder

NOTE: This information includes Bit Allocation, Scale Factor Select Information and Scale Factors.

single channel mode: audio mode, in which a monophonic audio programme is encoded within one bit stream

stereo mode: audio mode, in which two channels forming a stereo pair (left and right) are encoded within one bit stream

stuffing: one or more bits which may be inserted into the audio bit stream

NOTE: Stuffing bits are ignored by the audio decoding process. The purpose is to fill up a data field when required.

sub-band: subdivision of the audio frequency range

NOTE: In the audio coding system, 32 sub-bands of equal bandwidth are used.

sub-band samples: sub-band filter bank in the audio encoder creates a filtered and sub-sampled representation of the input audio signal

NOTE: The filtered samples are called sub-band samples. From 384 consecutive input audio samples, 12 consecutive sub-band samples are generated for each of the 32 sub-bands.

syncword: 12-bit code embedded in the MPEG Audio Layer II bit stream ISO/IEC 11172-3 [2], ISO/IEC 13818-3 [4] that identifies the beginning of an audio frame

Unequal Error Protection (UEP): error protection procedure which allows the bit error characteristics to be matched with the bit error sensitivity of the different parts of the bit stream

X-PAD data group: package of data used for one user application in the Extended Programme Associated Data (X-PAD)

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 300 401 [1] and the following apply:

AES	Audio Engineering Society
ASCTy	Audio Service Component Type
CIF	Common Interleaved Frame
CRC	Cyclic Redundancy Check
DAB	Digital Audio Broadcasting
DRC	Dynamic Range Control
EBU	European Broadcasting Union
EEP	Equal Error Protection
FFT	Fast Fourier Transform
F-PAD	Fixed Programme Associated Data
ID	Identifier of audio coding algorithm
ISO	International Organization for Standardization
LSb	Least Significant bit
LSF	Lower Sampling Frequency
M/S	Music/Speech
MPEG	Moving Pictures Expert Group
MSb	Most Significant bit
MSB	Most Significant Byte
PAD	Programme Associated Data
PCM	Pulse Coded Modulation
ScF	Scale Factor
ScF-CRC	audio Scale Factor - Cyclic Redundancy Check (error check)
ScFSI	Scale Factor Select Information
SMR	Signal-to-Mask Ratio
SPL	Sound Pressure Level
UEP	Unequal Error Protection
X-PAD	eXtended Programme Associated Data

3.3 Mathematical symbols

3.3.1 Arithmetic operators

For the purposes of the present document, the following mathematical symbols apply:

\wedge	Power
$/$	Integer division with truncation of the result toward zero; for example, $7/4$ and $-7/-4$ are truncated to 1 and $-7/4$ are truncated to -1
$Q(a/b)$	$Q(a/b)$ is the quotient part of the division of a by b (a and b positive integers)
$R(a/b)$	$R(a/b)$ is the remainder of the division of a by b
$\text{mod}(a,b)$ (b positive integer)	$\text{mod}(a,b) = \begin{cases} R(a/b) & \text{if } a \text{ is a positive integer} \\ R((b - R(-a/b))/b) & \text{if } a \text{ is a negative integer} \end{cases}$
(mod p)	Modulo p operation

3.3.2 Logical and set operators

For the purposes of the present document, the following mathematical symbols apply:

$\max [,\dots,]$	The maximum value in the argument list
$\min [,\dots,]$	The minimum value in the argument list
\oplus	Exclusive or
\cap	Set intersection
\cup	Set union
\setminus	Set exclusion: $\{-3, -2, \dots, 3\} \setminus \{0\}$ is the set of integers $\{-3, -2, -1, 1, 2, 3\}$

3.3.3 Functions

For the purposes of the present document, the following mathematical symbols apply:

\sin	Sine
\cos	Cosine
\exp	Exponential
$e^{(\cdot)}$	Exponential function
$\sqrt{\quad}$	Square root
\log_{10}	Logarithm to base 10
j	Imaginary unit, $j^2 = -1$
Rect	$\text{Rect}(x) = \begin{cases} 1 & \text{if } 0 \leq x < 1 \\ 0 & \text{elsewhere} \end{cases}$
δ	Kronecker symbol $\delta(i, j) = \begin{cases} 1 & \text{if } i = j \\ 0 & \text{if } i \neq j \end{cases}$

3.3.4 Constants

For the purposes of the present document, the following mathematical symbols apply:

π	3,14159265359...
e	2,71828182846...

3.4 C-language mathematical symbols

3.4.1 Arithmetic operators

For the purposes of the present document, the following C-language mathematical symbols apply:

+	Addition
-	Subtraction (as a binary operator) or negation (as a unary operator)
++	Increment
--	Decrement
*	Multiplication
DIV	Integer division with truncation of the result toward $-\infty$
%	Modulo operator. Defined only for positive numbers
log ₁₀	Logarithm to base 10

3.4.2 Logical operators

For the purposes of the present document, the following C-language mathematical symbols apply:

	Logical OR
--	------------

3.4.3 Relational operators

For the purposes of the present document, the following C-language mathematical symbols apply:

>	Greater than
≥	Greater than or equal to
<	Less than
≤	Less than or equal to
==	Equal to
!=	Not equal to

3.4.4 Assignment

For the purposes of the present document, the following C-language mathematical symbols apply:

=	Assignment operator
---	---------------------

3.4.5 Mnemonics

The following mnemonics are defined to describe the different data types used in the coded DAB audio bit-stream:

bslbf	Bit string, left bit first, where "left" is the order in which bit strings are written in the present document. Bit strings are written as a string of 1 s and 0 s within single quote marks, e.g. "1000 0001". Blanks within a bit string are for ease of reading and have no significance
bound	Number of first sub-band in joint stereo mode
ch	Channel. If ch has the value 0 the left channel of a stereo signal or the first of two independent audio signals is indicated
chlimit	Number of channels
dscf	Difference between two Scale Factors
gr	Granule of three sub-band samples per sub-band
nbal	Number of allocated bits per sub-band sample
nch	Number of channels; equal to 1 for single channel mode, 2 in other modes
rpchof	Remainder polynomial coefficients, highest order first
sb	Sub-band
sblimit	The number of the lowest sub-band for which no bits are allocated
scfsi	Scale Factor selection information
uimsbf	Unsigned integer, most significant bit first

The byte order of multi-byte words is most significant byte first.

3.4.6 Method of describing bit stream syntax

The bit stream described in clause 5 is the bit stream that exists in the DAB-receiver at the interface between channel decoder and audio decoder. The bit stream is described using the "C" software language which is used to program the processor which assembles the programme audio and associated data for channel coding. Each data item in the bit stream is in bold type. It is described by its name, its length in bits, and a mnemonic for its type and order of transmission.

The action caused by a decoded data element in a bit stream depends on the value of that data element and on data elements previously decoded. The decoding of the data elements and definition of the state variables used in their decoding are described in annex B. The following constructs are used to express the conditions when data elements are present, and are in normal type.

NOTE 1: This syntax uses the "C"-code convention that a variable or expression evaluating to a non-zero value is equivalent to a condition that is true.

while (condition) { data_element ... }	If the condition is true, then the group of data elements occurs next in the data stream. This repeats until the condition is not true.
do { data_element ... }	The data element always occurs at least once.
while (condition) if (condition) { data_element ... }	The data element is repeated until the condition is not true. If the condition is true, then the first group of data elements occurs next in the data stream.
else { data_element ... }	If the condition is not true, then the second group of data elements occurs next in the data stream.
for (expr1; expr2; expr3) { data_element ... }	expr1 is an expression specifying the initialization of the loop. Normally it specifies the initial state of the counter. expr2 is a condition specifying a test made before each iteration of the loop. The loop terminates when the condition is not true. expr3 is an expression that is performed at the end of each iteration of the loop, normally it increments a counter.

NOTE 2: The most common usage of this construct is as follows.

for (i = 0; i < n; i++) { data_element ... }	The group of data elements occurs n times. Conditional constructs within the group of data elements may depend on the value of the loop control variable i, which is set to zero for the first occurrence, incremented to one for the second occurrence, and so forth.
---	---

As noted, the group of data elements may contain nested conditional constructs. For compactness, the {} may be omitted when only one data element follows.

data_element []	data_element [] is an array of data. The number of data elements is indicated by the context.
data_element [n]	data_element [n] is the (n+1)th element of an array of data.
data_element [m][n]	data_element [m][n] is the (m+1),(n+1)th element of a two-dimensional array of data.
data_element [l][m][n]	data_element [l][m][n] is the (l+1),(m+1),(n+1)th element of a three-dimensional array of data.
data_element [m..n]	is the inclusive range of bits between bit m and bit n in the data_element .

3.5 Convention

Unless otherwise stated, the following notation, regarding the order of bits within each step of processing is used:

- in figures, the bit shown in the left hand position is considered to be first;
- in tables, the bit shown in the left hand position is considered to be first;
- in byte fields, the Most Significant bit (MSb) is considered to be first and denoted by the higher number. For example, the MSb of a single byte is denoted "b₇" and the Least Significant bit (LSb) is denoted "b₀";
- in vectors (mathematical expressions), the bit with the lowest index is considered to be first.

NOTE: Due to time-interleaving, this order of bits is not the true transmission order.

4 Introduction

The DAB system standard [1] allows audio (programme) services to be carried using either DAB audio or DAB+ audio. The present document defines the way that audio (programme) services are carried when using DAB audio (MPEG layer II audio coding).

Two sampling rates are permitted for DAB audio coding, 48 kHz and 24 kHz. Each audio frame contains samples for 24 ms or 48 ms, respectively, and each frame has a constant size. The audio frames are carried in one or two DAB logical frames, respectively. A range of bit rates and audio modes are available and the addition of Programme Associated Data (PAD) allows supplementary content to be provided.

5 DAB audio coding

5.1 Introduction

An overview of the principal functions of the audio coding scheme is shown in the simplified block diagram of the DAB audio encoder (see figure 1). The main characteristics of the audio coding system, like audio modes, bit rates and audio frame length are given in clause A.2, whereas the characteristics of the input audio signal are given in clause A.1.

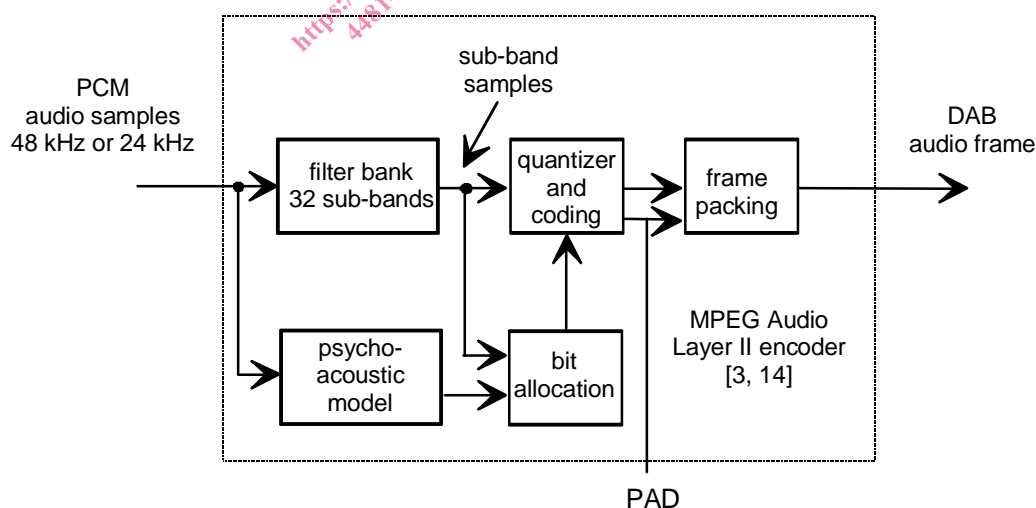


Figure 1: Simplified block diagram of the DAB audio encoder